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ABSTRACT

Researchers use data from a longitudinal child health survey in Rochester (New York) to investigate the relationship between chronic poor health and school outcomes among children. A model is presented that relates educational outcomes--academic achievement, intelligence test results, and attendance--to children's health and other personal characteristics, family socioeconomic background, and a number of school characteristics. Statistical analysis using simultaneous linear equations confirms that health factors do affect school outcomes, but that the effect varies with the type of health problem. Attendance is reduced by those illnesses that restrict strenuous activity or that interfere with peer or school interaction. In turn, decreased attendance tends to lower achievement. Chronic psychological problems, however, reduce achievement but do not lower attendance; and chronic physical problems tend to increase achievement. Special classes or tutoring for chronically ill children seem to raise academic achievement only for those younger than around eight years old. (Author/RW)

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SCHOOL OUTCOMES OF CHRONICALLY ILL CHILDREN AND THEIR SIBLINGS: A MULTIVARIATE APPROACH

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June 1981

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Abstract

The relationship between chronic poor health and school outcomes among children is investigated. A simultaneous 3SLS model is estimated in which achievement, attendance and I.Q. are the endogenous variables. The hypothesis that particular health characteristics are associated with differences in individual school outcomes is confirmed. For example, attendance is affected more by illnesses likely to interfere with school or peer interactions or difficulty doing only strenuous activity. Achievement is lowered by moderate to severe psychological problems. Including attendance as an endogenous variable increases its significance.

Other socioeconomic and school variables are included in the model, including mother working, marital status and special schooling. Policy implications are suggested.

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Introduction

Since the early sixties there has been a good deal of attention paid to educating the disadvantaged. Attention has been focused on the relationship between poverty and low educational attainment. Resources were shifted into education under the theory that education is a way out of the cycle of poverty and poor education. Studies evaluating the success of compensatory eduction focused on the outcome of the special programs such as Head Start, remedial education and on other factors which contribute to educational differences such as race, background factors and peer characteristics. (See for example, Hanushek, 1972; Summers and Wolfe, 1977; Averch, et al, 1972; Barnow and Cain, 1977; Winkler, 1975.)

One factor generally neglected in these studies is the role of health factors. Children with chronic illnesses or poor nutrition may not respond to educational opportunities in the same way as healthy or well nourished children. Children who are disadvantaged in one or both of these ways may suffer a number of adverse effects including brain damage, loss of learning time, interference with learning during critical periods of development and motivation and personality changes which influence responsiveness. (See for example, Cohn, E., 1971; Birch and Gassow, 1970; Blau, 1980; Epstein and Weisbrod, 1974; Cravioto and DeLicardie, 1973.)

Another group affected by chronic poor health may be the siblings of one of these children. Parents may spend more time and pay more attention to the ill child to the detriment of the health children in the family. Tensions may further influence their development. These factors may create another form of disadvantaged children who have less human capital than other children from similar socioeconomic backgrounds when they enter school and a less favorable home atmosphere in which to develop as they progress in school.

The purpose of this project is to investigate the factors affecting educational achievement of chronically ill children and their siblings. School, community, medical care and background factors are included. The goal is to both gain insight into the factors which influence the educational attainment of these groups and derive suggestions for policies aimed at improving their education achievement. Potentially this may also add to our knowledge of the link between health and low levels of knowledge.

Brief Review of the Literature

A number of studies (see Edwards and Grossman, 1979; Shakotko, Edwards and Grossman, 1980) have found a positive relationship between health and cognitive development. Children who begin life with poor health--very low birth weights, birth defects--may have low IQ's throughout their lives. Children who are poorly nourished or are frequently sick may miss school and/or be lethargic when attending school. Birth defects of vision, hearing, speaking may create problems in learning. Additional evidence from adults (see, for example, Wolfe, 1980) and from studies in developing countries (see Simmons and Alexander, 1978) suggests that chronic poor health leads to less human capital development. And, of course, a good deal of evidence suggests that poor health leads to morbidity--lower productivity in less developed countries (see Behrman, Wolfe, and Tunali, 1980, for references).

Other background factors are also important determinants of educational outcomes. Parent's education, amount of time spent with children, income, community characteristics are all considered important factors influencing cognitive development. (See for example, Jencks, C., 1972; Summers and Wolfe, 1977; Williamson, S., 1970; Levanto (1975))

Given that health and background factors are important determinants of cognitive development, the role that schools can play, particularly for children

who either begin life with poor health or develop abnormalities as children, has been investigated in a limited way, see, for example, Bishop, 1975; Johnson (ed.) 1968. Most of the studies have been simple direct bivariate appraisals of particular programs rather than more complete multivariate analyses.

In this study two types of educational outcomes are analyzed--achievement (cognitive development) and attendance at school. Attendance is considered to represent motivation along with health problems of the child. Since, attendance is likely to influence achievement and achievement, or lack of school success, affect attendance, a simultaneous model is appropriate. For the study of children with chronic health problems this model allows us to capture both the direct affects of health on achievement--for example, difficulties in concentrating--and the indirect effects through time missed in school.

More specifically the following model is proposed:

$$Y_1 = \alpha_1 X + \beta_1 H + \phi_1 I + \varepsilon_1$$

$$Y_2 = \alpha_2 X + \beta_2 H + \phi_2 I + \gamma_2 Y + \varepsilon_2$$

$$Y_3 = \alpha_3 X + \beta_3 H + \phi_3 I + \gamma_3 Y + \varepsilon_3$$

where

Y = a 1 x 3 vector of 2 school outcome measures namely achievement and attendance and IQ.

X = a matrix of socio-economic variables broadly defined including parent family characteristics such as income, family size, race, if parents work and mother's education, some of which are a prior set to = 0.

H = a matrix of own health characteristics including: 1) if condition is likely to interfere with peer interaction, likely to create difficulty concentrating, need for medical care visits, 2) actual number of medical care visits last year; and interviewer's response on whether child has trouble with strenuous or ordinary activities.

Z = a vector of school characteristics including if a parochial or public school, whether child is in special class or is being tutored.

I = matrix of individual characteristics of child including age, sex, sibling rank, and if the child has a handicapped sibling

$\alpha, \beta, \gamma, \phi,$ = coefficients to be estimated.

ε = a 1 x 3 vector of error terms.

The model is clearly a simultaneous model where health directly affects both achievement and attendance; attendance affects achievement; health has an indirect effect on achievement through attendance and low achievement affects attendance. I.Q. is controlled for, so that the achievement equation is a value-added equation. Health characteristics are assumed to be exogenous; that is, they are not affected by achievement, I.Q. or attendance.

Since the purpose of this model is to trace through the "full effect" of socioeconomic and health valuables on achievement, and since I.Q. is included in the achievement equation, we also estimate the effect of socioeconomic and a limited set of health variables on I.Q. For example, socioeconomic status is likely to 1) positively influence I.Q. ("genetics" and environment including available resources) and through I.Q. positively effect achievement (environment and resources). The sum of effects 1 and 2 provides an estimate of the total (direct and indirect) effect of socioeconomic status on a child's achievement.

We wish to go beyond the general question of whether health creates lowered school outcomes. What we wish to investigate is whether certain types of health problems are likely to lead to lowered cognitive development. For example, only those children with moderate to severe psychological problems may have learning problems or children who had chronic health problems most of their lives may either have continual school difficulties or adjust to their condition. Not all children are likely to respond in the same way.

Both sex and age may make a difference. Thus we wish to identify those "chronic health problems" which are likely to be important for cognitive development. Second, we wish to explore the endogenty issue. In most work on achievement, attendance is viewed as exogenous--as a factor influencing exposure to school inputs, or perhaps also capturing attitude towards school. In this type of specification, attendance sometimes has some limited influence on achievement. (See Summers and Wolfe, 1977 for example.) Viewing attendance as endogenous and part of a simultaneous model suggests that achievement affects attendance as well as the other way around. The expectation is that positive achievement will decrease absences, and that the simultaneous framework will show that attendance is a more important determinant of achievement than has previously been found.

Data

The data used in this project are part of the child health survey conducted over a period of years in Rochester, New York. The particular sample used is chronically ill school-aged children and a matched sample of well children. Besides a very detailed medical history including physical limitations, duration and prognosis, information collected includes: type of school attended, whether in a special class, whether tutored, attendance, ability based on a standardized test, I.Q., achievement bands, an assessment by the teacher of various types of school problems, medical care usage, parent's education, family size, family attitudes toward the child.

The specific variables included are described in Table 1. Some of the components of health variables were done in consultation with M.D.'s. Each International Classification of Diseases (I.C.D.) classification was rated

Table 1

Variable Descriptions

Child characteristics (non-health)

Endogenous:

I.Q.: Child's I.Q. score, based on the Quick Test

Days absent: number of days absent last marking period

Achievement: a five-value scale based on one of the following achievement tests; the Iowa Test of Basic Skills, the Standard Achievement [Tests], the New York State Readiness Test, the Iowa Tests of Educational Development, the New York State Survey, the Metropolitan Primary Form, B, the SATS and the PSAT, the Science Research Association [Test], the Gates McGinnities Reading Test, the NYS Reading and Arithmetic Test(s), the N[ew] Y[ork] S[tate] Minimum Competence Test, the N[ew] Y[ork] S[tate] Regents Qualification Test, the National Educational Development Tests, the Cooperative Primary Wide Range Achievement Tests, the California Achievement Tests, or the National Merit Scholarship Qualification Tests[s]. The schools were asked to recode the raw scores into the following bands: 1 = low, 2 = low normal, 3 = normal, 4 = high normal, or 5 = high.

Low achieving: dummy variable; 1 = parents or teachers have expressed concern about the child's school performance

Exogenous:

Age: child's age last birthday

Age 16-18: dummy variable; 1 = child is 16 or older; 0 = child is younger than 16

Female: dummy variable; 1 = female, 0 = male

Young mom: dummy variable; 1 = mother was less than 20 when child was born; 0 = mother was 20 or older

Sibling rank: child's rank in family; 1 = oldest, 9 = ninth or younger

Handicapped sibling: dummy variable; 1 = child has handicapped sibling; 0 = child does not have a handicapped sibling

Child characteristics (health)

Duration = 2/3 life: dummy variable; 1 = child has a disability which has existed for more than 2/3 of his or her life; 0 = child has no such disability

Duration 1/3 - 2/3 life: dummy variable; 1 = child has a disability which has existed for between 1/3 and 2/3 of his or her life; 0 = child has no such disability

Likely to create a concentration problem: dummy variable; 1 = child has a disability likely to make concentration difficult; 0 = child has no such disability
(Based on I.C.D. classification)

Likely to interfere with school interactions: dummy variable; 1 = child has a disability likely to interfere with physical activity or ability to communicate in the classroom; 0 = child has no such disability (Based on I.C.D. classification)

Problem with strenuous activity: dummy variable; 1 = interviewer judges that the child has a disability which interferes with strenuous activity; 0 = child judged not to have such a disability

Problem with ordinary activity: dummy variable; 1 = interviewer judges that the child has a disability which interferes with ordinary activity; 0 = child judged not to have such a disability

Moderate-severe psychological discomfort: dummy variable; 1 = child has a disability producing severe psychological discomfort; 0 = child has no such disability

Moderate-severe physical discomfort: dummy variable; 1 = child has a disability producing severe physical discomfort; 0 = child has no such disability

No doctor visits > 1: number of doctor visits > 1 during last year

School:

Tutored or special class: dummy variable; 1 = child attends a special class or is tutored; 0 = child attends no such class, receives no tutoring

SES (home production)

Mom's education: years of education completed by the child's mother (divided by 10)

Dad's age: age of father

Nonwhite: dummy variable; 1 = nonwhite, 0 = white

Occupational prestige (head): value of the Bogue occupational index (divided by 20); higher SES occupations have higher scores.

Income: family income in thousands of dollars

Previously married = dummy variable; 1 = mother not currently married; 0 = mother currently married

Number children: number of children in the family

Adults not working: number of parents and grandparents in the household, less the number of parents employed

Mother works: dummy variable; 1 = mother works, 0 = mother does not work

by an M.D. in terms of characteristics likely to influence school performance; these include "those likely to cause difficulties concentrating," "those likely to lead to problems relating to classmates--behavioral problems," those associated with long hospitalizations and those requiring frequent doctor visits. In addition, medical groupings originally done for these data by the Rochester researchers, such as moderate to severe psychological problems are also used.*

A third set are interviewer ratings of whether the illness interferes with a set of activity categories.

An alternative way to think of the relationship between cognitive development, health and socioeconomic factors, and one likely to lead to somewhat different emphasis is to concentrate on nature, nurture, history, and current health status as they affect cognitive development and motivation. The variables would then be discussed in terms of:

1) nature or predetermined factors. These include race, age, sex, sibling rank, and age of mother at birth.

2) nurture or discretionary factors which may include those factors that affect cognitive development and motivation. These include income, time availability measures such as whether or not the mother works, other adults at home, and efficiency factors such as parent's education and age.

3) history or prior events which are likely to directly affect educational outcomes. These include, duration of health problems, whether or not the child is in a special class, whether parent's or teachers express concern over the child's achievement, prior attendance, number of medical care visits and whether the child has a handicapped sibling.

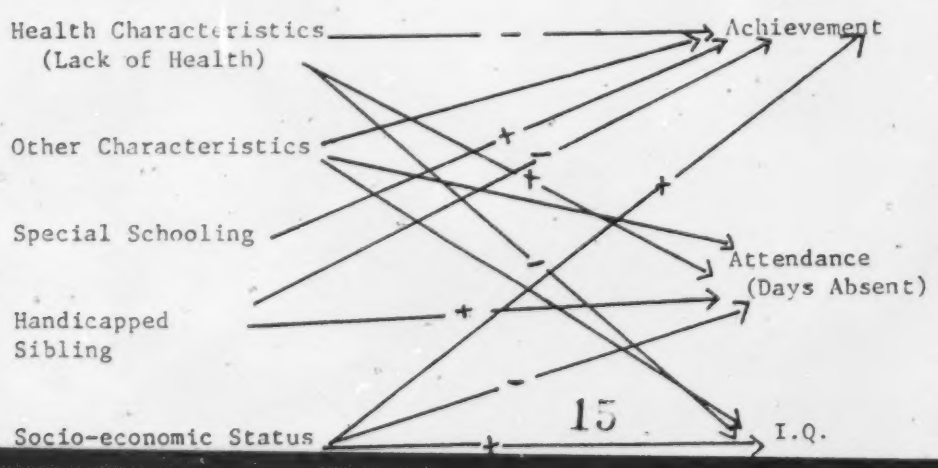
*See Chapter 3 in Haggerty, Roghman and Pless (1975)

4) current health status measured in terms of both psychological, behavioral and physical problems. These include moderate to severe psychological and physical problems, if illness is likely to interfere with school behavior, if illness is likely to create problems in concentration. While the actual model estimated would be the same, the emphasis in the discussion would differ, since the emphasis would be on the relative importance of nature and nurture.

Methodology

The model is estimated as a set of linear simultaneous equations. Generally, I.Q. would be viewed as recursive to the rest of the model, (determined prior to the school outcomes). However, since the I.Q. measure is based on a test given as part of the survey it may more appropriately viewed as simultaneous to the rest of the system, and a three equation simultaneous equation model the appropriate specification. Both a 3 equation simultaneous system and a 2 equation simultaneous system where I.Q. is estimated separately and considered recursive to the rest of the system are estimated. If the I.Q. module is recursive to the rest of the model, the parameter estimates of the 2 step model are consistent. In both cases the simultaneous part of the system is estimated using three stage least squares (3SLS).

Figure 1
Simplified Graphical Presentation of the Model



In order to identify the system not all health and socioeconomic variables can be included in each equation of a simultaneous system. Therefore a set of apriori assumptions are made. They include 1) that I.Q. is influenced by long-term socioeconomic variables (permanent income as measured by the head's socioeconomic status, mother's education, race and father's age; 2) by health problems generally associated with psychological difficulties and whether or not they are classified as having a chronic health problem and; 3) by additional factors found important in other studies such as sibling rank and number of siblings. In other words, by factors having long term effects on available resources in the form of parent's time and material resources, the efficiency with which they are used, plus certain health difficulties.

Attendance is specified to be affected by current socioeconomic variables (current income, adults at home) own characteristics (sex, age, an extensive list of health problems emphasizing physical problems, medical care, a differentiation of certain of the problems by the child's sex, whether or not (for healthy children) the child has an ill sibling, and whether or not the child is a low achiever.

Achievement is specified to be affected by I.Q., attendance, certain long run socioeconomic variables (race, father's age, permanent income as measured by the head's socioeconomic status) short run variables which may temporarily disrupt school performance (marital break-up of parents, mother working), health problems likely to interfere with achievement such as psychological problems (likely to create a concentration problem, moderate to severe psychological or physical discomfort), duration of the health problem to see if adjustment occurs, special schooling interacted with age to see if these provide some compensation, and certain child specific variables such as age, sex, age of mother at birth and for healthy children whether or not the child has an ill sibling.

Before moving on to the results several caveats that should be kept in mind are suggested. In many ways this work should be viewed as explanatory and suggestive rather than definitive. One, it is based on data collected at one point in time in one community. The findings may not be applicable in the future or in other areas. Two, the sample of well and ill children, 248; 124 well, 124 chronically ill is quite small and since it oversampled chronically ill children perhaps should be interpreted with extreme caution in terms of application to well children. While weighting might overcome this, appropriate weights which would include population information along with socioeconomic information (a micro data base) are not readily available. Three, the achievement measure used is quite "aggregative", (see appendix). Since different tests were given in different schools, the schools were asked to scale the test results into five bands of achievement where 1 = low; 2 = low normal; 3 = normal; 4 = high normal; 5 = high. Finer distinctions might permit better more in depth analysis. Four, little is known about the schools attended or the resources available to each child (including actual time spent by the parents) so little can be said in terms of educational policy. Five, on a more technical note, point four suggests there are important unobserved variables. If they are uncorrelated with the included variables so that the residual or error term is uncorrelated with the included variables, the results should not be biased. If however, the assumption is not valid, our results will be biased. Six, again on a technical note*, since achievement takes on only 1 of 5 values, the assumption

*If only a single achievement equation were being estimated, a multinominal logit would be the appropriate specification. However, the simultanity of the system and continuous nature of the other dependent variables dominated the choice of methodology.

of independent normally distributed disturbance terms may be violated. Nevertheless, the unique combination of health, socioeconomic characteristics and school outcomes permits an exploration that cannot be done with most other data sets so that despite these caveats, this work can be viewed as making an important exploratory contribution to understanding how particular types of poor health affect educational outcomes.

Empirical Results

We begin our discussion of results by focusing on the central topic of interest: the impact of own health characteristics on school outcomes. Since the 3 equation simultaneous system results and 2 equation results are nearly the same, the 3 equation results are discussed. The biggest difference, as expected is the coefficient on the I.Q. variable in the achievement equation; however, since health is not significant in the I.Q. equation this has little effect on the health results.

Health

Table 2 provides an overview of these effects, while Table 3 presents the actual estimates. In general, the hypotheses that particular health characteristics influence school outcomes and do so differentially is validated. For example, health problems which are likely to interfere with school interactions (that is to interfere with communication in the classroom or group physical activities) significantly increases days absent as do health problems which interfere with strenuous activity. Alternatively, health problems which interfere with ordinary activities do not affect attendance. These differences are not apriori obvious.

None of the health problems available in this sample were related to measured I.Q.

Table 2

A Summary of Health Effects on School Outcomes

Health Problem	School Consequence
Likely to create concentration problems	Not significant. Slight suggestion of negative effect on achievement.
Likely to interfere with school or peer interaction	Increase days absent; indirectly decrease achievement
Has problems with strenuous activities	"Big" increase in days absence: indirectly decrease achievement
Has problems with ordinary activities	No effect
Moderate to severe psychological discomfort	Decrease days absent. Decrease achievement
Moderate to severe physical discomfort	Increase female days absent. Increase boys achievement. No effect on girls achievement.
Duration: more than 2/3rd of child's life	No effect on attendance or achievement.
Duration: 1/3 to 2/3rd of child's life	No effect.
Doctor visits	No direct effect. If "health" not included, increases days absent.
Hospitalized during last year	No effect.
Handicapped sibling	Some indication of decrease in achievement.

Table 3
Empirical Results
Simultaneous Model
3SLS Results

	I.Q.			Days Absent		Achievement		X̄	σ
	OLS	3 Eq	3SLS	2Eq 3SLS	3EQ 3SLS	2Eq 3SLS	3EQ 3SLS		
Child Characteristics (non-health)									
Endogenous									
Achievement								3.50	1.08
I.Q./100						2.08 (5.03)	3.62 (2.92)	1.11	.16
Days absent						-.07 (2.40)	-.07 (2.28)	2.51	.62
Low achieving				.94 (1.69)	.93 (1.67)			.55	.50
Exogenous									
Age/10						-2.76 (1.44)	-2.95 (1.41)	1.14	.30
Age/10 squared						1.23 (1.52)	1.30 (1.48)	1.39	(.71)
Age 16-18				1.70 (1.99)	1.72 (2.03)			.12	(.33)
Female				.10 (.17)	-.12 (.19)	.08 (.67)	.10 (.80)	.47	(.50)
Young mom						-.60 (1.84)	-.56 (1.74)	.05	(.22)
Sibling rank	-.005 (.50)	-.004 (.37)						2.12	(1.18)
Handicapped sibling				-.72 (.14)	-.72 (.83)	-.30 (1.53)	-.28 (1.45)	.13	(.34)
Child Characteristics (health)									
Handicapped group	-.005 (.21)	-.005 (.19)		.05 (.08)	.06 (.08)	-.23 (.99)	-.22 (.94)	.50	(.50)
Duration: > 2/3 life						.26 (1.16)	.28 (1.22)	.21	(.41)
Duration: 1/3 - 2/3 life						-.10 (.43)	-.07 (.28)	.17	(.38)
Likely to create concent. prob.	-.01 (.47)	-.01 (.46)		-.11 (.61)		-.11 (.61)	-.11 (.62)	.28	(.45)
Likely to interfere school interactions	-.01 (.39)	-.01 (.38)		1.79 (1.63)	1.79 (1.63)			.10	(.30)
Prob. with strenuous activities				3.86 (3.36)	3.85 (3.37)			.09	(.28)
Prob. with ordinary activities				-.45 (.46)	-.43 (.44)			.10	(.30)
Mod-severe psychol. discomfort	-.04 (1.16)	-.04 (1.15)		-3.35 (2.22)	-3.36 (2.24)	-.42 (1.72)	-.35 (1.37)	.09	(.28)
No. Dr. visits > 1				.03 (.70)	.03 (.73)			1.80	7.25

Empirical Results (continued)

	I.Q.			Days Absent		Achievement		$\bar{X}$	σ
	OLS	3 Eq	3SLS	2Eq 3SLS	3EQ 3SLS	2Eq 3SLS	3EQ 3SLS		
School									
Tutored or spec. class						2.53 (1.30)	2.42 (1.21)	.03	(.18)
Tutored or spec. × age/10						-2.59 (1.60)	-2.43 (1.42)	(.04)	(.21)
SES (home production)									
Mom education/10	.22 (4.74)	.28 (4.62)						1.26	(.24)
Dad's age/10	.03 (1.72)	.03 (1.65)				-.25 (2.17)	-.26 (2.21)	4.10	(.62)
Nonwhite	-.12 (2.43)	-.12 (2.39)				-.48 (1.37)	-.25 (.65)	.04	(.20)
Occup. prestige (head)/10	.02 (2.06)	.02 (2.07)				.14 (2.93)	.09 (1.49)	5.40	(1.38)
Income wks/10				-5.83 (2.62)	-5.79 (2.62)			1.28	(.57)
Income/10 squared				1.72 (2.39)	1.71 (2.39)			1.96	(1.75)
Previously married						-.20 (.72)	-.15 (.53)	.06	(.24)
Number children	-.001 (.11)	.002 (.31)						3.45	(1.37)
Mother works						.35 (2.66)	.34 (2.54)	.39	(.49)
Constant	.65 (7.01)	.66 (7.06)		5.96 (3.54)	5.95 (3.55)	3.08 (2.80)	1.76 (1.37)		

Turning to the detailed results regarding the impact of health problems on attendance and achievement, moderate to severe psychological discomfort has the largest direct negative impact on achievement (see columns 5 and 6, Table 3). The 2 estimates (2 equation 3SLS and 3 equation 3SLS) suggests that the presence of this health characteristic reduces the output variable by .4 of an achievement band. Alternatively moderate to severe physical discomfort is associated with higher achievement: approximately a 1/3 increase between 2 achievement bands for children with this health problem. (This may be an "Einstein" type effect. A person with physical limitations has fewer alternative uses of time. S/he may be unable to go outside and play ball or other sports for example. This reduces the opportunity cost of time spent studying, so s/he spends more time studying--or more generally, doing school related work, than a child not physically disabled.) None of the other health problems have direct significant effects on achievement including duration. The insignificance--though positive sign of duration indicating a child has had the condition two-thirds or more of his or her life suggests some compensation has taken place. Parents may have spent more time, the child adjusted or other forms of investment (more books, tutoring...) been made to compensate for the long term health condition. Thus, particular health problems have negative, positive or neutral direct association with achievement.

Some health factors have strong (positive or negative) influences on attendance. Among females moderate to severe physical problems have the largest effect on attendance, increasing, on average, the days missed by really four and one-half. Since mean days missed is 2.5 this is nearly a 180% increase! Among males however, there is no similar effect on attendance of physical discomfort. Having problems with strenuous activity increases

days missed by 3.85 for both males and females, an increase of 150%. Children who have health problems which are likely to interfere with school interactions miss, on average, 1.8 additional days of school, a 70% increase over the mean, smaller than the others but still a big effect.

Alternatively children who have moderate to severe psychological discomfort attend school much more than other children; they miss 3.35 fewer days. Parents of such children may fear that if they fall behind, it will be particularly difficult for them to catch up or this may reflect their parent's desire to reduce the amount of time they have to contend with such problems. School may represent a welcome relief so they are sent to school every day.*

Other included health variables do not significantly influence attendance. Among these, somewhat surprisingly is number of doctor visits. However, when health characteristics were excluded from the equation, number of doctor visits had a small (.07) "almost" significant effect on attendance. Thus a number of health measures are related to school attendance for this sample. Most, but not all, increase absences--decrease attendance.

Since attendance is significantly related to achievement there are further indirect health effects of particular health problems on achievement. These include a .27 deduction in achievement due to presence of problems with strenuous activities (3.85 x -.07); a .13 reduction on achievement from having a health problem likely to interfere with school interactions, a .31 reduction for girls who have moderate to severe physical discomfort (this balances the positive direct physical discomfort on achievement), and a .23 increase in achievement for children with moderate to severe psychological problems.

*Jay Chambers suggested this possibility.

In summary then, particular health characteristics are associated with large differences in individual school outcomes. Not all chronic health problems have an effect, not all are in the same direction and the size of the impact differs. Table 2 summarizes the effects. Those problems identified as having large negative effects on school outcomes can be viewed as targets for special concern.

Since it is also possible that the underlying structure differs for well and chronically ill children, separate runs were conducted for the well and chronically ill subgroups--omitting health variables--and an F test performed.* Since the resulting test statistic was not statistically significant, the structure is assumed to be the same for both subgroups. For certain subgroups of the ill population this may not be true, but the small size of the sample prohibits adequate testing of this question. This finding, if it holds across other children, implies that ommission of health from educational production function studies does not result in omitted variable bias--at least from this source.

Handicapped sibling. The second topic of major interest is whether having a chronically ill sibling creates school outcome problems for his or her well sibling. The answer in this sample is perhaps--the negative sign on achievement is consistent with this expectation but it is not quite significant. Since children in the sample may have ill siblings who are not in the sample, and this would bias the results toward zero the near significance and size of the coefficient in the achievement equation suggests that children with chronically ill siblings may perform less well in school than other children. It is a hypotheses that should be further explored.

*The same variables that are included as independent variables in the reported runs, except for the health variables were included in the equations for subgroups. This is approximately equivalent to interacting each non-health variable with a health variable, i.e., using interaction terms.

School characteristics. Unfortunately, only very limited information on schooling was made available for this project. This includes type of school--city, public, suburban public, parochial and others; and whether the child is in a special class or is being tutored and an area socio-economic variable which may measure peer or classmate level.

Type of school using these broad classifications, does not have any significant effect on attendance or achievement and neither does neighborhood socio-economic level once the child's families own socio-economic level is controlled. The school finding is probably due to aggregation bias--not all schools in a category have similar characteristics. We could instead use a set of dummies for particular schools but we would need nearly one per child!

There is some indication that special classes or tutoring do "make a difference for achievement." Among young children--up to age 8 or so the effect is positive, then the effect is insignificant while at older ages, the effect--or association with achievement is negative. Several things may explain this pattern: 1) at older ages, those least successful are pulled out so the causality runs the other way--and in fact--these children may gain from the special attention. 2) younger children feel less stigmatized and/or can take better advantage of the special education efforts. 3) programs aimed at younger children are "better" more productive programs.

These results suggest that it may be useful to explore these special programs both the "more effective" ones directed at younger children and the less effective ones aimed at older children.

Relationship between outcome measures. Another main hypotheses suggested in the discussion of the model above is that treating attendance as endogenous would increase its importance as a determinant of achievement. The results of the simultaneous and single OLS equations seem to support this hypothesis: attendance shows the hypothesized relationship to achievement: children with more days absent do less well. Associated with each additional day absent of a marking period, there is a .07 reduction or movement toward a lower achievement band. When this is compared to OLS runs: (see appendix) using the same variables as in the 3SLS runs, the results on absences were -.04 (3.05). Thus, while significant and of the same sign the coefficient is smaller--.04 compared to .07 or approximately one half the simultaneous result. Thus, other work which does not find much effect of attendance on achievement may be doing so because they omit the endogeneity of attendance and this misspecification "hides" the true effects. Thus, to the extent it is possible to generalize from these results from one community, a high payoff to increased attendance is suggested.* Policies aimed at increasing attendance may be "more effective in achievement terms" than has previously been suggested although policy induced attendance may not have the same achievement results.

The achievement measure included in the attendance equation is not current achievement but rather a variable representing teacher's or parent's concern about the pupil's school work. The idea is to capture a concern

*Given the income results in the days absent equation, days absent do not seem to reflect vacations or other reasons associated with higher income.

that the child has been performing below the teacher's or parent's expectation.* This is preferred to achievement since the test date may occur before, during or after the marking period for different children. The advantage of this low achieving measure is that it applies to a time period similar to attendance.

The results suggest that children with achievement problems tend to be absent more often; and that the association is large--.92 on a mean of 2.5. Seeing teacher dissatisfaction, or parent dissatisfaction may make a child wish to avoid school--or more directly, poor performance may make a child reluctant to attend school and face yet another disappointment.

Since this feeds back to further reduce achievement--by reducing attendance--parents, teachers, and school systems may wish to consider how to deal with the under achievement, attendance link.

Other Results

Since these data have a wealth of "home production" type variables, it seems useful to comment on some--but only some of the additional results.

Mother's education has a very strong impact on measured I.Q.: "28 points" on a 100 normal test and thus a very strong indirect impact on achievement. This is likely to reflect both genetics and early home environment. Interestingly, once I.Q. is controlled in achievement, there is no further effect on mother's education on achievement suggesting either the relative importance of genetics and early environment or that the input beyond this early measure only maintains what has been accomplished earlier. (An example

*The questions are: teacher is greatly or somewhat concerned about child's effort or achievement, parent worries often or always about school grades or homework or parent is not satisfied with school work or parent reports the child does not do well in school.

of diminishing marginal returns.) The results suggest that this is the single most important determinant of I.Q. and thus has a large indirect effect on achievement.

Having older parents in particular an older father is associated with a higher measured I.Q. This may reflect the higher age at childbirth of persons with more educational training, or possibly greater efficiency in child rearing. The direct effect on achievement is insignificant--suggesting perhaps a trade-off between the factors above and more difficulty communicating, greater differences in the education process from the days of the parent's education, a different less child oriented lifestyle or diminishing marginal returns.

Occupational prestige of the head of the household is associated directly and indirectly with higher achievement. The association is positive with I.Q. and positive with achievement. This may reflect both higher income and resources available but also reflect education and motivation and possibly the type of reading materials available in the home. Current income is associated with fewer days absent--though at a decreasing rate.

In terms of time constraints neither number of children in the family or sibling rank have any independent effect on school outcomes, once the other factors are controlled. The results on "available time" show no effect on attendance, and perhaps surprisingly indicate that children with mothers who work show higher achievement. This does not reflect the fact that mothers of healthier children are more likely to work. The finding is the same among the well children subsample and in fact somewhat stronger--.36 (1.94)--40% of the mothers of chronically ill children work compared to 38% of the mothers of well children. It is also not marital status, since this is controlled in the equation. Thus, another explanation is necessary. Perhaps,

these mothers are more motivated and particularly motivated to be sure their children do well in school; these mothers work so their children have opportunities for after school education such as music lessons, etc., or these children strive to do well to get attention. Whatever the explanation, considering the increase in mother's labor force participation, it is a reassuring finding. Similarly the insignificance of the marital status variable suggests "less reason for concern" with how well the children do in school if a family breaks up.

Conclusions

All of this suggests that children with certain health problems show lowered school outcomes compared to other children, while children with other health problems seem able to compensate for their health problems and do as well as healthy children.* The type of program best suited to chronically ill children depends on the type of health problem they have. Recognizing specific differences and orienting programs to them will potentially improve the effectiveness of the education process.

In particular, attendance is affected more by illnesses likely to interfere with school or peer interactions, difficulty doing only strenuous activity, and moderate to severe physical discomfort among girls. Children with these health problems should, perhaps be the target for an attendance program or at least, further analyses as to why they miss more school. Alternatively children with moderate to severe psychological discomfort are quite likely to attend school.

*No doubt this must reflect the parent's ability to adjust.

Achievement is lowered by moderate to severe psychological problems (perhaps making it hard to place great weight on what is happening in the classroom) but "increased" for those with moderate to severe physical discomfort. Perhaps school work serves as an "escape" or participation in other activities is reduced. One appropriate target group then is those with psychological problems.

When attendance is considered on endogenous variable and part of a simultaneous model it becomes a much more "significant" factor influencing achievement. Indirectly those with health problems reducing attendance do less well in terms of achievement, and some form of compensation may be needed to improve achievement.

There is some indication that having a handicapped sibling reduces school achievement--although further exploration is appropriate considering the sample size and the matching of siblings.

Finally, perhaps worthy of note are the following: 1) to the extent that special classes and tutoring seem to have a positive effect it is only for young children. 2) Health conditions as opposed to doctor visits seem to influence attendance. 3) Children of split families showed no significant reduction in achievement. 4) Children of working mothers do better in terms of school achievement. These last two are comforting in this period when the probability of being in these situations is increasing.

All of these findings and implications should, however, be taken primarily as suggestive and as input into further exploration. Since the estimations omit parental responses to health and detailed school factors, the results may reflect both the structural (or technical effect of health on school outcomes) and certain behavioral responses. They may thus either over or under estimate the true structural effects.

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Appendix
Empirical Results
OLS Estimation

	I.Q.	Days Absent	Achievement
	OLS	OLS	OLS
Child Characteristics (non-health)			
Endogenous			
I.Q./100			2.09 (5.02)
Days absent			.04 (3.05)
Low achieving		.70 (1.25)	
Exogenous			
Age			-2.45 (1.38)
Age squared			1.08 (1.44)
Age 16-18		1.60 (1.88)	
Female		.19 (.32)	.07 (.55)
Young mom			-.60 (1.83)
Sibling rank	-.005 (.50)		
Handicapped sibling		-.68 (.79)	-.28 (1.43)
Child Characteristics (health)			
Handicap Group	-.005 (.21)	.10 (.14)	-.25 (1.08)
Duration: > 2/3 life			.22 (.97)
Duration: 1/3 - 2/3 life			-.11 (.45)
Likely to create concent. prob.	-.01 (.47)		-.10 (.53)
Likely to interfere-school interactions	-.01 (.39)	1.74 (1.58)	
Prob. with strenuous activities		3.76 (3.26)	
Prob. with ordinary activities		-.56 (.57)	
Mod-severe psychol. discomfort	-.04 (1.16)	-3.19 (2.11)	-.35 (1.47)
Mod-severe psychol. x female		.22 (.11)	
Mod-severe physical discomfort		-.13 (.12)	.26 (1.37)
Mod-severe physical x female		4.82 (3.13)	
No. Dr. visits > 1		.04 (.87)	

Appendix Table--continued

	I.Q.	Days Absent	Achievement
	OLS	OLS	OLS
School			
Tutored or spec. class			2.47 (1.26)
Tutored or spec. x age			-2.55 (1.56)
SES (home production)			
Mom education	.22 (4.74)		
Dad's age	.03 (1.72)		-.26 (2.23)
Nonwhite	-.12 (2.43)		-.51 (1.45)
Occup. prestige (head)	.02 (2.06)		.15 (3.16)
Income		-5.79 (2.60)	
Income squared		1.72 (2.39)	
Previously married			-.25 (.91)
Number children			
Adults not working		.81 (1.57)	
Mother works			.36 (2.69)
Constant	.65 (7.01)	6.08 (3.61)	2.85 (2.78)
R^2	.22	.24	.32

t-statistics in parentheses.